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ABSTRACT

The purpose of this paper is to describe the development of both the instrumentation and the software of an emerging, high-technology system used for science instruction. A marriage of computer and television technologies has evolved into an exciting new learning system called interactive videodisc instruction. The development of the hardware components of a specific interactive videodisc system, the development of two instructional programs using this system for university general biology courses, the actual use of this technology in an instructional setting, and the potential for future development using this space-age technology are given. Student perceptions of the use of an interactive videodisc system for biology instruction in university general biology are also illuminated. (Author/JN)

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DEVELOPMENT OF HIGH-TECHNOLOGY SCIENCE INSTRUCTION: A CASE HISTORY OF AN INTERACTIVE VIDEODISC SYSTEM

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The purpose of this paper is to describe the development of both the instrumentation and the software of an emerging, high-technology system used for science instruction utilizing both the microcomputer and the laser videodisc player. This system is termed interactive videodisc instruction (IVI). A characterization how this technology can be utilized in a typical instructional setting and a prognosis for future development of such spage-age instruction is also given.

Theoretical Basis

A number of justifications for computer-assisted instruction (CAI) in science education have been offered since it was first introduced about two decades ago. Among the original arguments were: economizing on laboratory facilities and materials, saving instructional time, individualization of student work, drill and practice, and rapid evaluation of student response and feedback. As computers became more sophisticated, rationale extended to: highly motivating and interactive simulations and games which enrich the educational experience, being able to manipulate abstract concepts in a more concrete manner, and the ability to interact with phenomena normally not accesible in a regular classroom (Ellis, 1984). Henize-Fry, Crovello, and Novak (1984) have argued by example that CAI can operate consistent with Ausubelian learning theory. A meta-analysis of 54 studies of CAI versus traditional teaching in postsecondary classrooms revealed higher examination scores by approximately 3% favoring CAI and with effect sizes which are small but significant (about .2 S.D.) (Kulik, Kulik, and Cohen, 1980). Furthermore, these studies found CAI to have significant and remarkable saving in instructional time.

Crovello (1984) has declared CAI in biology to currently be in a rapid growth and diversification phase. One direction is the linking of microcomputers to other recent technologies such as a laser videodisc player. Experimental evaluation of such instruction is only beginning (Leonard 1984).

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Procedures

Computers and computer-assisted instruction have been with us now for nearly two decades. Microcomputer instruction has been a visible instructional component on most college campuses during most of the 1980s. A major limitation of traditional CAI is that the resolution and reality of the images on the screen, even with high resolution graphics, is still not very real or life-like.

On the other hand, video instruction, particularly television, has been on college campuses in some form for well over two decades. The life-like sequences possible by high resolution video images, especially those in color, give a dimension of detail and reality needed for quality biology instruction.

Recently, the use of a laser videodisc player has become possible and has many advantages. The disc, itself, has some 50 000 concentric groves. Each grove may contain one audio and one video tract which will hold the equilavent of a slide or a traditional movie frame. Played at approximately 30 frames per second, the disc contains enough storage for an entire movie with video resolution far surpassing broadcast television. Individual tracks or sequences of tracks on the disk can be sought and played almost instantaneously. The modest microprosessor in the Pioneer Model 2000 videodisc player, for example, can be programmed to search for and play a series of frames representing a desired scenario from anywhere on the disc. Furthermore, the tiny laser beam, in addition to being partially responsible for the high resolution, reads below the surface of the disc. The disc can be coated for protection and played an almost unlimited number of times without eroding the quality of the data contained. Such discs are relatively inexpensive to mass produce once the mastering process is completed.

The idea for combining the microcomputer and the videodisc player has been around as long as the microcomputer, but the major obstacle was to get the video player and the computer to communicate with each other. The computer uses a magnetic-based binary coding system and the videodisc player uses light and audio signals. In the early 1980s engineers at the University of Nebraska Videodisc Group were experimenting with an interface between the TRS-80 Model III microcomputer and the Pioneer Model 2000 videodisc player. This interface was not costly and permitted superimposing (overlaying) onto the screen the computer-generated text over color video materials from the disc.

In 1982 the Annenberg Foundation and the Corporation for Public Broadcasting funded a project to develop interactive videodisc instructional programs for introductory college biology, chemistry and physics. The major thrust was to see if the interactive videodisc system could provide an alternative or significant addition to the traditional laboratory exercises in these courses.

The following strategies were employed to produce the biology interactive videodisc lessons. Content experts and educators first identified the topics (titles) to be taught to students. In biology, two quite different programs were invisioned, each for a different reason. "Respiration" was a simulation of a rather standard laboratory exercise typically done in freshman biology in which the student investigates the relationship between environmental temperature and the respiration rates of three very different organisms. "Climate and Life," a vivid exploration of the physical and biological characteristics of the ten major biomes of the world, represented a global field trip to specific geographical areas of Earth. It was therefore selected as an example of a type of instruction not possible in a conventional college lecture or laboratory setting.

Specific concepts related to each lesson were identified, as well as sources of data available to the student. In "Climate and Life", for example, motion scenes of plant and animal life in the ten biomes, climatograms showing annual temperature and rainfall patterns for each biome, definitions of terms, descriptive narratives of biomes and climatic patterns, reasons for seasons, and pictoral and narrative descriptions of world wind patterns were all available from the videodisc. Instructional designers, biologists, and educators identified possible instructional strategies available to the student, particularly alternative pathways toward progressing through the lesson. Methods of evaluating student progress through the lesson were developed. A worksheet was later constructed for the student to record data and respond to some of the questions presented by the IVI system.

A complex flow chart (a "storyboard" in television circles) was then generated. This indicated all the introductory or required information presented to the student, the task requirements of the lesson, the possible routes a student would take, when quizzes or remedial components would be introduced, and how the resource data on the videodisc could be accessed. This flow chart was heuristically three dimensional because of many possible combinations of anticipated routes taken by a student.

The computer programming was the next phase of development and it was one for which we greatly underestimated the time needed. The programers had difficulty, at first, in preserving the scientific and educational integrity of the lesson as they developed the programs for the lessons from the flow chart. After several meetings between programmers and lesson developers, there was an eventual sharing of thoughts and meeting of the minds, an aspect proving to be very beneficial to the project.

Most of the programming was done simultaneously to the mastering of the video segments onto the videodisc. A videotape containing all the video materials with digital codes for each frame was sent to 3M Company for mastering. Since the identical

video segments were needed to do the programming, a simulator was utilized. This elaborate and expensive machine utilizes a copy of the same video tape sent to 3M, but, unlike the common videotape player, can advance and search specific segments nearly as rapidly as a videodisc player. Since the TRS-80 disk drives read only one side of the disk, space for the program was at a premium. Therefore, UCSD Pascal was used along with a authoring language which was compatible to the TRS DOS system. Even then, the program for each of the biology lessons nearly filled one side of a double-density disk. Some computer graphics were also generated in cases in which student-collected data needed to be displayed or where appropriate video materials to illustrate specific biological phenomena were not found.

Conclusions and Implications for Science Teaching

Field tests on these IVI lessons have provided some interesting evaluative data. There is a perception by students using these materials that the lessons take less time than would an actual "hands on" laboratory investigation and that there is significant economy of their own time. This is especially true when the time needed for temperature equilibration and data collection in the "Respiration" lesson is considered. Being able to greatly speed up experimental "wait-time" means that much more or much greater depth of material can be covered in the same time as in the real laboratory activity. On the other hand, there is also a clear perception that the video sequences are only photos or simulations of the real apparatus or phenomenon. Some students stated disappointment in not being able to "touch" the apparatus. All students expressed excitement in being able to experiment with a high-technology learning system.

There appears to be little doubt that interactive videodisc instruction will continue to develop and be used for instruction. At present, there are at least two major obstacles. First, the cost of such a system is relatively high. This is particularly high when one considers that one system will effectively serve only a small group of students. Second, until most microcomputers are compatable with each other, distribution of software will be limited, as well as the capability of students to utilize their own home microcomputers for review and practice of the corresponding IVI lessons. I do envision these obstacles being greatly ameliorated by the early 1990s. Grant support for development of this technology appears to be quite available. The advent of the Panasonic laser videodisc recorder/player will speed the development process. There is now experimental work being done on an erasable laser recorder/player. Typically, the development of quality software will lag behind the hardware available. The potential for new technology and educational strategies are enormous and equally exciting.

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